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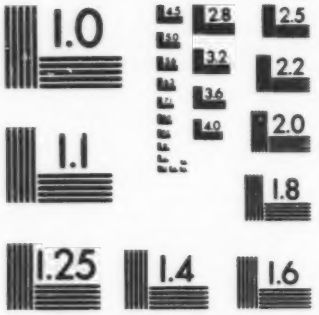

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SITE SELECTION PROCESS

PHASE 3B: SELECTION OF CANDIDATE SITES

Sensitive Crops

ECOLOGISTICS LIMITED

AND

DELOITTE, HASKINS AND SELLS ASSOCIATES

OCTOBER 31, 1984

ecologistics limited CONSULTANTS IN ENVIRONMENTAL RESOURCE MANAGEMENT

Westmount Place, 50 Westmount Road N., Suite 225, Waterloo, Ontario N2L 2R5 Tel. (519) 886 - 0520

October 31, 1984

Dr. B.D. Mitchell
Ontario Waste Management Corporation
2 Bloor Street West
11th Floor
TORONTO, Ontario
M4W 3E2

Dear Sir:

Re: Final Report: "SITE SELECTION PROCESS - PHASE 3B:
SELECTION OF CANDIDATE SITES - Sensitive Crops"

We are pleased to forward herewith our final report for the above-noted study. The map which accompanies this report is found in the "SITE SELECTION PROCESS - PHASE 3B: SELECTION OF CANDIDATE SITES - Technical Data Map Portfolio."

This report documents the analyses which were undertaken during Phase 3B fn identifying agricultural crop sensitivity to a broad range of airborne contaminants.

This report has been prepared by the staff of Ecologistics Limited and Deloitte, Haskins and Sells Associates together with Dr. D.P. Ormrod.

The results of this work were incorporated into our broader agricultural assessment which appears in our technical report, "SITE SELECTION PROCESS - PHASE 3B: SELECTION OF CANDIDATE SITES - Agriculture."

We are pleased to have been of service.

Yours very truly,

ECOLOGISTICS LIMITED

D.R. Cressman, M.Sc., P.Ag.
President

DRC/vw

Enclosure

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EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

This report documents the analysis of potential sensitivity of agricultural crops to possible Ontario Waste Mangement Corporation (OWMC) facility emissions. Sensitive crops were applied as a factor in Chapter 4 of the report, "SITE SELECTION PROCESS - PHASE 3B: SELECTION OF CANDIDATE SITES - Agriculture." The present report outlines the steps followed in identifying potentially sensitive crops and it documents the extent of such crops grown commercially in the OWMC candidate areas.

SCOPE AND METHOD

A study of this kind is almost without precedent. Consequently, it was necessary to develop both the list of potentially sensitive crops and the method for identifying their area and location in the OWMC candidate areas.

The site selection factor "sensitive crops" relates to two of the site selection objectives, "minimize risk to human health" and "minimize

environmental impact." The focus of analysis was the potential for direct and/or indirect impact to farming enterprises within the study areas. Impacts would occur if a) airborne contaminants degraded the yield and/or quality of farm products, or b) if, because of long-term bioaccumulation of such contaminants, farm products became unmarketable.

The sequence of activities in the assessment of crop sensitivity was:

1. A list of agricultural crops grown in the candidate areas was developed from county crop production statistics.

2. The relative sensitivity of these crops to accumulation of contaminants and to injury by contaminants was established based on knowledge of accumulation pattern within plants and on a review of literature on sensitivity to injury.

3. A list of relatively sensitive crops was established based on their potential for injury and/or transmitting contaminants to consumers.

4. Values for these crops were calculated for each enumeration area (E.A.'s) within the candidate areas established in the OWMC Interim Phase 3 Report. All E.A.'s within candidate area boundaries or containing a fraction thereof were included to obtain crop areas. Five-year production statistics data were used to obtain average crop values per unit area.

PREMISES AND POSTULATES

PREMISES

Candidate area boundaries as established in the OWMC Interim Phase 3 Report formed the basis for determining which enumeration areas would be examined.

The ongoing work of the Ontario Research Foundation on potential emissions and air dispersion served as starting points for this analysis.

POSTULATES

The study postulates that it is possible, for the purposes of making an initial comparison of alternative locations for an OWMC facility, to identify a group of agricultural crops that would be most sensitive to contaminants. This postulate is made in light of the best available knowledge about the response of agricultural crops to airborne contaminants and the quality of the available information about the location of such crops.

It is postulated that the data on crop occurrence in the 1981 Census of Agriculture, expressed at the enumeration area level, are the most recent and detailed available from among the various alternate data sources.

It is further postulated that the use of "dollar value per hectare of enumeration area" as a relative index (for the sensitive crop group) would meet the need for comparing crop sensitivities among siting options. This would provide a common basis for comparing sites which have different areas and type of relatively sensitive crops.

STATUS OF DATA

Very little information is available on crop sensitivity to the types of contaminants that might be emitted by this type of facility. We are attempting to utilize the best available information based on reports of crop sensitivity to contaminants from varying industrial and urban sources but the information is fragmentary and incomplete.

The data obtained from the literature demonstrate the relative sensitivity to contaminants of agricultural crops grown in the OWMC candidate areas. The most sensitive crops were identified in terms of area and location from the 1981 Census of Agriculture. Values of these crops on a per hectare basis were determined from statistics collected annually by the Ontario Ministry of Agriculture and Food.

Despite the relatively coarse level of detail available from enumeration area data, the data are considered suitable for defining

relative differences in sensitive crop occurrence across the candidate areas. Furthermore the data are considered suitable for use in the initial comparison of potential sites during Phase 3B.

MAIN FINDINGS

Information was not available on the types and potential dose levels of specific contaminants. In its absence all of the potential crop contaminants were assumed to be produced. While the nature and extent of any potential crop effects could not be determined, it was possible to develop a basis for relative comparisons of facility siting options.

A large number of field crops and specialty crops are grown in the candidate areas. They can be grouped into forages, grains, other seeds, leafy, roots, vegetable fruits and fruits. These crops vary in sensitivity to environmental contaminants. Crop sensitivity to contaminants is related to direct injury, growth and quality effects and to the role played in accumulating contaminants and passing them, in the food chain, to animals and humans. The latter role varies according to the nature of the crop. Forage crops and leafy crops have a high potential for providing contaminants to animals and humans that consume them while grains, seeds and some vegetable fruits have a relatively low potential.

The available information on crop sensitivity is based largely on visible injury effects. Little information is available on the growth, yield and quality effects of contaminants. A descriptive summary is provided on visible injury, growth effects, accumulation of toxicants and food chain role for each group of crops. The overall relative sensitivity of each crop to injury and relative accumulation of contaminants were estimated based on the available information and on species characteristics.

The summaries of sensitivity and roles in the food chain were used as a basis for selection of sensitive crop categories. The area and value of these relatively sensitive crops were obtained from production statistics, using five years of Ontario Ministry of Agriculture and Food statistics on an enumeration area basis.

Mapping of the crop values revealed the highest in the fruit and vegetable growing areas near Fonthill and Vineland in the Niagara Region, Ancaster in the Region of Hamilton-Wentworth, and east of Omagh in Halton Region. Lowest values of potentially sensitive crops were noted in the area immediately south of Niagara Falls.

CONCLUSIONS AND RECOMMENDATIONS

Based on the review of scientific literature, 23 agricultural crop categories grown in OWMC candidate areas were identified as being relatively sensitive to contaminants. This sensitivity takes into account potential risks to human health via the food chain and potential effects on the economic viability of producers of such crops.

The value per hectare of enumeration area of these relatively sensitive crops grown in the OWMC candidate areas in 1981 was mapped. This mapping can be used as a basis for comparing relative risk to the selected group of crops in areas subject to influence from an OWMC facility.

Additional refinement is needed in the data base and in the determination of most probable contaminants from the facility prior to the selection of a preferred site(s). During Phase 4A the relative risks to the food chain should, if possible, be assessed and reported separately from the risk of economic impact.

CHAPTER 1

INTRODUCTION

The sensitivity of agricultural crops to possible contaminant emissions is one of the considerations for selection of candidate sites for OWMC facilities.

Relative to the total area encompassed by OWMC candidate areas, crop production occupies most of the land base. Thus it was necessary to determine, as far as possible, the absolute and relative sensitivities of each crop to contaminants that might escape from the facilities.

Relevant issues concerning possible impacts on crop production include sensitivity to direct injury and implications for transmission in the food chain of sorbed contaminants to animals and humans when crops are consumed. Either form of impact, if it occurred, could have economic consequences to the affected farm operator(s).

This report presents a preliminary summary of crop sensitivities to prospective contaminant emissions. It gives a separate listing of the species with the most direct injury sensitivity and/or the greatest influence in the food chain.

There is little published information upon which to base a study of this kind. There are many deficiencies in published crop sensitivity data that have implications in this study. These deficiencies, together with the lack of precise knowledge of the kinds and amounts of contaminants that will occur, make it difficult to present a clear and precise picture at this time.

Information on crop injury sensitivity to contaminants that might emanate from an OWMC facility is fragmentary and ambiguous. There has been a general lack of thorough definitive comparative sensitivity research to date. Very few species and contaminant classes have been studied by anyone in detail. Cultivars within species may differ greatly in sensitivity. The fact that many species' names do not appear in lists of sensitive species does not mean these species are insensitive; more likely it means that the species have not been tested. As well, published classifications of sensitivity are not based on uniform procedures and terminology. Thus, not only is there little or no information on crop injury sensitivity to many contaminant categories but also there are shortcomings in sensitivity classifications based on literature reviews. Any compilation of published ratings of crop injury by toxicants should only be used as a general subjective indication of sensitivity.

Nevertheless, we have attempted to obtain the best available information on sensitivity to injury. In combination with general knowledge of differences in toxicant accumulation patterns in crops as

part of the food chain for humans and livestock, we have used the information to identify a representative list of 23 relatively sensitive crop categories. It should be noted that crops not on this list may also be sensitive to some toxicants under some circumstances.

CHAPTER 2

METHODOLOGY

The sequence of crop production parameters selected for analysis in identifying crop importance in relation to sensitivity to contaminants included:

1. A list of agricultural crops produced in the study area developed from county crop production statistics.

2. Crop characteristics that determine accumulation patterns within plants and thus the food chain.

3. Crop sensitivity to direct injury by contaminants based on literature reports on sensitivity to the contaminants that may be emitted by the facility.

4. Values of the crops with potential for direct injury and/or those with considerable influence in transmitting contaminants in the food chain for assessment of crops at risk in the study area.

The data were gathered from sources indicated in Table 1.

TABLE 1

DATA SOURCES FOR AGRICULTURAL CROP ANALYSIS

Data Type	Source of Data	Published By	Level of Detail/Scale	Date	Area Coverage
Agricultural crops	Maps of Agricultural Land Use	Land Resource Research Institute, Agriculture Canada	1:25,000	1982	Regional Municipalities of Niagara, Haldimand, Norfolk
		Ontario Ministry of Agriculture and Food	1:50,000	1982-83	Regional Municipalities of Hamilton-Wentworth, Halton, Peel, York, Durham and Brant County
Crop sensitivities	Literature	Various reports and journals	Species, cultivars	Various	Worldwide
Indications of intensity and economic performance in agriculture	Census of Agriculture	Statistics Canada	Townships and Municipalities	1981	Regional Municipalities of Niagara, Haldimand-Norfolk, Hamilton-Wentworth, Halton, Peel, York, Durham and Brant County

CHAPTER 3

DATA ANALYSIS

AGRICULTURAL CROPS IN THE STUDY AREA

A list of agricultural crops produced in the candidate areas was developed from the 1981 crop production statistics of the Ontario Ministry of Agriculture and Food (Table 2). These crops were grouped into field crops: forages, grains, other seeds; and specialty crops: leafy, roots, vegetable fruits, and fruits.

CROP CHARACTERISTICS AND TOXICANT ACCUMULATION

There are two main characteristics determining the sensitivity of crops to contaminants that might be emitted from an OWMC facility. First, the crops may be sensitive to one or more contaminants emitted and be directly affected in terms of visible injury, and/or growth and yield reduction, and/or decreases in quality. Second, the crops may intercept and possibly accumulate contaminants that then are passed along in the food chain to animals and humans. The importance of the latter role is very dependent upon

TABLE 2

AGRICULTURAL CROPS PRODUCED IN THE STUDY AREA

Field Crops:

Forages

- Alfalfa
- Clover
- Corn
- Grass

Grains

- Barley
- Buckwheat
- Corn
- Oat
- Rye
- Wheat

Other Seeds

- Bean
- Soybean
- Sunflower

Specialty Crops:

Leafy Crops

- Asparagus
- Cabbage, Cauliflower Broccoli
- Lettuce

Root Crops

- Beet
- Carrot
- Onion
- Potato

Vegetable Fruits

- Snap Bean
- Sweet Corn
- Cucumber
- Pea
- Tomato

Fruit

- Apple
- Apricot
- Cherry
- Grape
- Peach
- Pear
- Plum, Prune
- Strawberry

Source: Agricultural Statistics for Ontario, Publication 20, Ontario Ministry of Agriculture and Food, 1981.

plant morphology as it affects interception and accumulation of contaminants and upon the parts of the plant that are consumed. A descriptive summary of the basis for crop sensitivities (Table 3) was prepared to indicate many of the salient features noted above. This summary provides some additional qualitative information on the state of knowledge of growth effects.

The entire shoot of forage crops is consumed by livestock. Any contaminant present on or in these plants will be ingested by animals, whether or not the plant itself is directly injured by the contaminant. As leaves will directly intercept particulate and gaseous emissions, forage crops could have important food chain roles in passing on to livestock the contaminants on and in the leaves. Similarly, leafy salad crops, in which the entire leaf is consumed by humans, may accumulate contaminants which may be harmful to humans even if not to the plant itself. Washing of such produce may remove superficial leaf surface contamination.

Grains and other seeds are consumed directly by livestock and humans or processed for their use. The grains and seeds are generally protected from the external environment during growth by coverings of leaves or pod walls. This prevents direct deposition of fall-out on the surfaces of the grains or seeds. Any contaminants accumulated by grains or seeds must be translocated within the plant from the soil or from the exposed surfaces. In general, less contaminant is accumulated in grains and seeds than in

TABLE 3

RELATIVE SENSITIVITY TO INJURY AND ACCUMULATION BY CROP GROUPS

Field Crops

Forages (Entire plant consumed by livestock)
Visible injury: Legumes - sensitive. Grasses - intermediate.
Growth effects: Not well known.
Accumulation of toxicants: Relatively high levels.
Food chain role: Very important. Livestock feed to meat and milk.

Grains (Dry grains consumed by livestock and humans)
Visible injury: Intermediate.
Growth effects: Not well known.
Accumulation of toxicants: Relatively low levels in dry grains.
Food chain role: Less important.

Other Seeds (Dry seeds consumed by livestock and humans or processed for human use)
Visible injury: Generally sensitive.
Growth effects: May be substantial growth and yield reductions.
Accumulation of toxicants: Relatively low levels in dry seeds.
Food chain role: Less important. Livestock feed, human food, processed products (e.g. cooking oils).

Specialty Crops

Leafy Crops (Entire plant consumed by humans)
Visible injury: Wide range of sensitivity.
Growth effects: Quality reduction more important economically than growth retardation.
Accumulation of toxicants: Relatively high levels.
Food chain role: Very important. Direct human consumption.

Root Crops (Root portion consumed by humans)
Visible injury: Intermediate.
Growth effects: Not well known.
Accumulation of toxicants: Relatively low levels except on surface.
Food chain role: Less important. Direct human consumption.

Vegetable Fruits (Fruit or part of fruit consumed by humans)
Visible injury: Intermediate to sensitive.
Growth effects: Generally substantial growth and yield reductions.
Accumulation of toxicants: Intermediate levels.
Food chain role: Important. Entire fruit exposed and consumed (bean, cucumber, tomato). Surface contamination may be consumed.
Fruit protected by leaves (corn) or ovules only consumed (pea): May be less important. Surface contamination may not be consumed.

Fruits (Entire fruit consumed by humans)
Visible injury: Intermediate.
Growth effects: Not well known.
Accumulation of toxicants: Intermediate levels.
Food chain role: Relatively low levels of contaminants except on surface. May have greater impact as a result of surface contamination. Generally less important than for leafy crops.

leaves. Similarly, root crops generally accumulate less contaminant in the edible root portion than in leaf tissue (Cottenie et al. 1976), although surface contamination may be a problem unless the roots are washed or peeled.

Vegetable fruits and fruit crops are those in which the fruit or part of the fruit is consumed by humans. The entire surface may be exposed to the environment as in snap bean, cucumber, tomato, apple, peach and cherry fruits or the fruit may be protected by coverings during growth as in sweet corn and green peas. Contaminants may be translocated into the fruit tissues from the soil, from fruit surfaces, or from other plant surfaces, but the concentrations in fruit tissues are generally lower than in leaves. As for root crops, surface contamination of fruits would need to be removed by washing or peeling to avoid transmitting contaminants to consumers.

The other portions of grain, seed, root and fruit crops are generally not utilized for food by humans or livestock. Such residues are usually returned to the soil as organic matter. During plant decomposition, any remaining contaminants may move to the soil where they may accumulate to be taken up by subsequent crops growing in that soil.

The relative sensitivities of crops to direct contamination in terms of edible tissue composition have been summarized in Table 4. This table attempts to provide an indication of the relative levels of edible tissue concentration of toxicants that would be present considering both direct

TABLE 4

RELATIVE ACCUMULATION OF CONTAMINANTS IN EDIBLE TISSUE

Field Crops:	
Forages	
Alfalfa	High
Clover	High
Corn	High
Grass	High
Grains	
Barley	Low
Buckwheat	Low
Corn	Low
Oat	Low
Rye	Low
Wheat	Low
Other Seeds	
Bean	Low
Soybean	Low
Sunflower	Low

Specialty Crops:	
Leafy Crops	
Asparagus	High
Cabbage, Cauliflower Broccoli	High
Lettuce	High
Root Crops	
Beet	Intermediate
Carrot	Intermediate
Onion	Intermediate
Potato	Intermediate
Vegetable Fruits	
Snap Bean	Intermediate
Sweet Corn	Low
Cucumber	Intermediate
Pea	Low
Tomato	Intermediate
Fruits	
Apple	Intermediate
Apricot	Intermediate
Cherry (sweet and sour)	Intermediate
Grape	Intermediate
Peach	Intermediate
Pear	Intermediate
Plum, Prune	Intermediate
Strawberry	Intermediate

Source: Derived from the principles summarized in Table 3. These ratings do not discriminate between direct contamination and contamination by translocation.

surface contamination and contamination by translocation from other plant parts and from the soil.

CROP SENSITIVITY TO CONTAMINANT-INDUCED INJURY

The list of contaminant classes presented by ORF (1984)[1] was used to form the basis for a literature search for information on relative sensitivity of the crops produced in the study area to contaminant-induced injury. The tabulation of available information on crop sensitivity is presented in Appendix A. The presentation of ratings from several references was intended to convey the general trends in sensitivity classification, including contradictions. In general, the published sensitivity information is based on visible injury responses. There is little information on growth and yield effects. Very few studies of dose-response relationships exist. It is not possible to present quantitative relationships of contaminants and yield for this reason.

The overall sensitivity of each crop to injury that might be caused by a mixture of contaminants was developed in a subjective manner from the literature information summarized in Appendix A (Table 5). The overall evaluations were based on a subjective combination of the individual sensitivities to contaminants. It should be emphasized that these ratings

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[1]Ontario Research Foundation, 1984. Site Selection Process - Phase 3B: Selection of Candidate Sites - Atmospheric Conditions.

TABLE 5

RELATIVE SENSITIVITY TO INJURY BY CONTAMINANTS

Field Crops:	
Forages	
Alfalfa	High
Clover	High
Corn	Intermediate
Grass	Intermediate
Grains	
Barley	Intermediate
Buckwheat	Intermediate
Corn	Intermediate
Oat	Intermediate
Rye	Intermediate
Wheat	Intermediate
Other Seeds	
Bean	High
Soybean	High
Sunflower	Intermediate

Specialty Crops:	
Leafy Crops	
Asparagus	Low
Cabbage, Cauliflower Broccoli	Intermediate
Lettuce	High
Root Crops	
Beet	Intermediate
Carrot	Intermediate
Onion	Intermediate
Potato	Intermediate
Vegetable Fruits	
Snap Bean	High
Sweet Corn	Intermediate
Cucumber	Intermediate
Pea	Intermediate
Tomato	Intermediate
Fruits	
Apple	Intermediate
Apricot	Intermediate
Cherry (sweet and sour)	Intermediate
Grape	Intermediate
Peach	Intermediate
Pear	Intermediate
Plum, Prune	Intermediate
Strawberry	Intermediate

Source: Derived from the literature review summarized in Appendix A. Each sensitivity rating represents a subjective averaging of all published information for that species.

sensitivities to contaminants. It should be emphasized that these ratings are largely based on reports of visible injury responses. The ratings may reflect growth, yield and quality responses to the extent that the occurrence of visible injury indicates impairment of these attributes.

SELECTION AND VALUATION OF MOST SENSITIVE CROPS

In order to provide a basis for comparing alternative siting locations for OWMC facilities it was necessary to develop a single index for sensitive crops. The need for an index arises from the variable areas and types of crops grown in the vicinity of different siting options. In the vicinity of one option there may be few crops grown but they may be of very high value, whereas, in the vicinity of another siting option there may be extensive crops but of low economic value. The means chosen for comparing such situations was an index of dollar value per hectare of enumeration area.

The foregoing summaries of sensitivity and roles in the food chain of all crops grown in the study region were used as the basis for selection of 23 relatively sensitive crop categories. This list of crop categories was developed by selecting from Tables 4 and 5 those crops which are identified as having "high" sensitivity. Also included in the list were all other crops which have edible tissues exposed to the atmosphere, i.e. the vegetable fruits, cucumbers and tomatoes, and all of the fruits.

The latter were included because they are crops for which the edible portion is directly exposed to the atmosphere and which may be consumed in whole by humans without peeling or washing. None of these crops has a protective husk or shell. The resulting list therefore represents potential risks to both human health and the economic viability of producers of such crops.

For the purpose of documenting the extent of sensitive crops in the study area, it was necessary to utilize data from the 1981 Census of Agriculture. This, in turn, necessitated a correlation of terminology for some of the crop categories that differ between the census and the OMAF production statistics. Table 6 lists the 23 sensitive crop categories as defined in the census and gives the correlated OMAF terms as used in Tables 2, 4 and 5.

Hectares of crops grown were obtained from the 1981 Census of Agriculture on an Enumeration Area[1] (E.A.) basis for all E.A.'s which are in whole or in part within the candidate areas. A tally sheet was devised (Table 7) to permit calculation of the crop value in each E.A. for each of the sensitive crops on a unit area basis. A final calculation was made for the value per hectare of E.A. for the sensitive crop group. The analysis was limited to those crops identified in the census categories as noted above.

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[1]The smallest geographic unit for which census data are available. The unit is defined according to a population range of 125 rural to 375 urban households and its boundaries do not cut across geographic areas recognized by the census.

TABLE 6

SENSITIVE AGRICULTURAL CROPS

FIELD CROPS

Forages

- Corn for ensilage*(Forage corn)**
- Oats for fodder (Oats)
- Other fodder crops (Various)
- Tame hay (Alfalfa, clover and grass)
- Improved pasture (Alfalfa, clover grass)

Other Seeds

- Dry field bean (Bean)
- Soybean

SPECIALTY CROPS

Leafy Crops

- Asparagus
- Cabbage
- Cauliflower
- Broccoli
- Lettuce

Vegetable Fruits

- Snap bean
- Cucumber
- Tomato

Fruits

- Apple
- Apricot
- Cherry (sweet and sour)
- Grape
- Peach
- Pear
- Plum and prune
- Strawberry

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*Crop classification terms utilized in the Census of Agriculture, 1981.

**Terms utilized in the Agricultural Statistics for Ontario, Publication 20, OMAF, 1981 which appear in Tables 2, 4 and 5 and differ from the Census of Agriculture terms.

TABLE 7

PRELIMINARY SENSITIVE CROP ANALYSIS TALLY SHEET

E.A. No. _____ Date _____

County _____ Prepared by _____

Checked by _____

CROPS	ACREAGE (ha)	VALUE/HA ($)	GROSS VALUE ($)
Soybean			
Corn for ensilage			
Tame Hay			
Oats for fodder			
Other fodder crops			
Dry field bean			
Asparagus			
Beans (wax-green-snap)			
Broccoli			
Cabbage			
Cauliflower			
Cucumber			
Lettuce			
Tomato			
Apple			
Pear			
Plum and prune			
Cherry (sweet)			
Cherry (sour)			
Peach			
Apricot			
Strawberry			
Grape			
Improved Pasture			
TOTALS			

Size of E.A. _____ $ Value/Ha of E.A. _____

List of crops derived from Table 6, the area from the 1981 Census of Agriculture, Statistics Canada, and the value/ha from Appendix B.

A dollar value per hectare was calculated for each crop from published production statistics available from the Ontario Ministry of Agriculture and Food.[2] Five years of data were used to obtain average values. These values were calculated, where possible, on a county basis (Appendix B). The values for dry field beans are not available. Since the reported areas for these crops are small, they were not included in the calculations.

The values for the sensitive crops range from a low of $9.60 to a high of $835.03 per hectare of E.A. with the majority below $120.00.

The per hectare value of sensitive crops in each E.A. is listed in Appendix C. These values were mapped to determine if any patterns were evident within the candidate areas. As indicated on Map E.S1, included in the "SITE SELECTION PROCESS - PHASE 3B: SELECTION OF CANDIDATE SITES - Technical Data Map Portfolio," the lowest values of potentially sensitive crops are located in the area south of Niagara Falls, and in Peel Region. High values are located near Fonthill and Vineland in the Niagara Region, near Ancaster in the Region of Hamilton-Wentworth, and east of Omagh in Halton Region.

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[2]Agricultural Statistics for Ontario, Publication 20, Ontario Ministry of Agriculture and Food, 1978 to 1982.

CONCLUSIONS

Based on the review of scientific literature, 23 agricultural crop categories were identified as being relatively sensitive to contaminants. This sensitivity takes into account potential risks to human health via the food chain and potential effects on the economic viability of producers of such crops.

The value per hectare of E.A. of the relatively sensitive crops grown in the OWMC candidate areas in 1981 will be used during the analysis of alternative site locations to establish, in a general sense, the relative risk to sensitive crops in areas subject to the influence of OWMC facilities. Should the zone of influence of some site alternatives extend beyond the candidate area boundary, the E.A. crop values can be calculated where required.

Additional refinement is needed in the data base and in the determination of most probable contaminants in the emissions prior to the selection of a preferred site(s). During Phase 4A the relative risks to the food chain should, if possible, be assessed and reported separately from the risk of economic impact.

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APPENDIX A

LITERATURE REVIEW OF SENSITIVITY TO INJURY OF CROPS GROWN IN THE STUDY AREA

Key to Symbols: As-Arsenic, B-Boron, Cd-Cadmium, Cl-Chlorine, Cr-Chromium, 2,4-D-2,4-dishlorophenoxyacetic acid, F-Fluoride, HCl-Hydrogen chloride, Hg-Mercury, H_2S-Hydrogen sulfide, NH_3-Ammonia, NO_2-Nitrogen dioxide, No_x-Nitrogen oxides, Oz-ozone, PAN-Peroxyacetyl nitrite, Ph-Lead, SO_2-Sulfer dioxide, V-Vanadium, Zr-Zirconium.

Alfalfa

Reference	Rating	Contaminants
EPA	Sensitive	O_3, SO_2, NO_2, Cℓ
	Intermediate	PAN
	Insensitive	F
NRCC (15019)	Sensitive	Salt
NRCC (15391)	Sensitive	As
AAAS	Sensitive	Cℓ, O_3
NRCC (15015)	Sensitive	SO_2

Apple

Reference	Rating	Contaminants
EPA	Sensitive	SO_2, NO_2, 2,4-D
	Intermediate	F
	Insensitive	PAN
NRCC (18467)	Insensitive	H_2S
AAAS	Sensitive	SO_2
NRCC (15015)	Intermediate	SO_2

Apricot

Reference	Rating	Contaminants
EPA	Insensitive	O_3
	Sensitive/intermediate	F
NRCC (19252)	Sensitive	B
NRCC (15015)	Intermediate	SO_2

Asparagus

Reference	Rating	Contaminants
EPA	Insensitive	F, NO_2
NRCC (15391)	Insensitive	As
NRCC (15015)	Intermediate	SO_2

Barley

Reference	Rating	Contaminants
EPA	Sensitive	O_3, SO_2, NO_2
	Intermediate	PAN
	Sensitive/Intermediate	F
NRCC (15019)	Insensitive	Salt
NRCC (15017)	Sensitive	Cr
NRCC (16736)	Intermediate	Pb
NRCC (15015)	Sensitive	SO_2

Dry Field Beans, Beans (wax etc.)

Reference	Rating	Contaminants
EPA	Sensitive	O_3, SO_2, NO_2 (Pinto) Hg
	Intermediate	NO_2, Cℓ, HCℓ
	Insensitive	F
NRCC (15019)	Sensitive	Salt
NRCC (15391)	Sensitive	As
NRCC (16736)	Sensitive	Pb
AAAS	Sensitive	SO_2
M & F	Sensitive	O_3 (Tempo-indicator plant)

Beet

Reference	Rating	Contaminants
EPA	Intermediate	PAN
	Sensitive	SO_2
	Insensitive	O_3
NRCC (15019)	Intermediate	Salt
NRCC (15391)	Intermediate	As
NRCC (16736)	Sensitive	Pb
AAAS	Sensitive	PAN
NRCC (15015)	Sensitive	SO_2

Buckwheat

Reference	Rating	Contaminants
EPA	Sensitive	O_3, SO_2
	Intermediate	Cℓ
	Insensitive	NH_3
NRCC (18467)	Sensitive	H_2S

Cabbage, Cauliflower, Broccoli

Reference	Rating	Contaminants
EPA	Intermediate	O_3, SO_2, F, NO_2, 2,4-D
	Insensitive	PAN
	Sensitive	SO_2 (broccoli)
NRCC (15019)	Sensitive	Salt
NRCC (18132)	Sensitive	V
NRCC (15391)	Insensitive	As
NRCC (15015)	Sensitive	SO_2 (broccoli)
	Intermediate	SO_2 (cabbage, cauliflower)

Carrot

Reference	Rating	Contaminants
EPA	Sensitive	SO_2, NO_2
	Intermediate	O_3, PAN
	Insensitive	F
NRCC (15019)	Sensitive	Salt
NRCC (15391)	Insensitive	As
AAAS	Sensitive	O_3
NRCC (15015)	Sensitive	SO_2

Cherry

Reference	Rating	Contaminants
EPA	Sensitive/Intermediate	O_3
	Intermediate	F, 2,4-D, HCℓ
	Insensitive	Hg
NRCC (18467)	Insensitive	H_2S
NRCC (15015)	Insensitive	SO_2

Clover

Reference	Rating	Contaminants
EPA	Sensitive	O_3, PAN, SO_2, NO_2
	Intermediate	F
NRCC (15019)	Sensitive	Salt
NRCC (18467)	Sensitive	H_2S
NRCC (15391)	Sensitive	As
NRCC (15015)	Sensitive	SO_2

Corn, Sweet Corn

Reference	Rating	Contaminants
EPA	Intermediate	NO_2, 2,4-D
	Insensitive	PAN, SO_2
	Sensitive/Intermediate	O_3, F
	Intermediate/Insensitive	Cℓ
NRCC (15019)	Sensitive	Salt
NRCC (16739)	Sensitive	Hg
NRCC (15391)	Intermediate	As
NRCC (15017)	Sensitive	Cr
NRCC (16736)	Intermediate	Pb
NRCC (15015)	Insensitive	SO_2

Cucumber

Reference	Rating	Contaminants
EPA	Sensitive	SO_2
	Intermediate	O_3, Cℓ
	Insensitive	PAN, F
NRCC (18467)	Sensitive	H_2S
NRCC (15391)	Sensitive	As
NRCC (15015)	Insensitive	SO_2

Grape

Reference	Rating	Contaminants
EPA	Sensitive	O_3, 2,4-D
	Sensitive/Intermediate	F
NRCC (15391)	Insensitive	As
AAAS	Sensitive	O_3
NRCC (15015)	Insensitive	SO_2
M & F	Sensitive	O_3 (Ives-Indicator plant)

Grass

Reference	Rating	Contaminants
EPA	Sensitive	O_3, PAN, SO_2
	Insensitive	H_2S
	Sensitive/Intermediate	F, NH_3
	Intermediate/Insensitive	NO_2, Cℓ
NRCC (15019)	Sensitive	Salt (orchardgrass)
	Intermediate	Salt (perennial rye, tall fescue)
NRCC (15017)	Insensitive	Cr (perennial rye)

Lettuce

Rference	Rating	Contaminants
EPA	Sensitive	PAN, SO_2, NO_2
	Insensitive	O_3
NRCC (15019)	Sensitive	Salt
NRCC (16743)	Sensitive	Cd
AAAS	Sensitive	PAN
NRCC (15015)	Sensitive	SO_2
M & F	Sensitive	NO_x (Indicator plant)

Oat

Reference	Rating	Contaminants
EPA	Sensitive	O_3, PAN, SO_2
	Sensitive/Insensitive	NO_2
	Intermediate	F
NRCC (15019)	Insensitive	As
NRCC (16736)	Sensitive	SO_2
NRCC (15015)	Sensitive	SO_2

Onion

Reference	Rating	Contaminants
EPA	Sensitive	O_3
	Intermediate	Cℓ
	Insensitive	PAN, SO_2, NO_2
NRCC (15019)	Sensitive	Salt
NRCC (15391)	Sensitive	As
AAAS	Sensitive	O_3
NRCC (15015)	Insensitive	SO_2

Pea

Reference	Rating	Contaminants
EPA	Sensitive	SO_2, NO_2
	Intermediate	O_3
	Insensitive	F
NRCC (19252)	Sensitive	Zr
NRCC (16739)	Sensitive	Hg
NRCC (18132)	Sensitive	V
NRCC (15391)	Sensitive	As
NRCC (16736)	Insensitive	Pb
AAAS	Sensitive	Ethylene
NRCC (15015)	Sensitive	SO_2

Peach

Reference	Rating	Contaminants
EPA	Insensitive	O_3
	Intermediate	2,4-D, Hg
NRCC (15015)	Intermediate	SO_2

Pear

Reference	Rating	Contaminants
EPA	Sensitive	NO_2
	Insensitive	F, O_3, 2,4-D

Plums and Prunes

Reference	Rating	Contaminants
EPA	Sensitive/Insensitive	F
NRCC (19252)	Sensitive	B
NRCC (15015)	Intermediate	SO_2

Potato

Reference	Rating	Contaminants
EPA	Sensitive	O_3
	Intermediate	NO_2, 2,4-D
	Insensitive	SO_2, F
NRCC (15019)	Sensitive	Salt
NRCC (15391)	Insensitive	As
AAAS	Sensitive	O_3, PAN
NRCC (15015)	Insensitive	SO_2

Rye

Reference	Rating	Contaminants
NRCC (15391)	Insensitive	As
NRCC (16736)	Intermediate	Pb
NRCC (15015)	Sensitive	SO_2

Soybean

Reference	Rating	Contaminants
EPA	Sensitive	O_3
	Intermediate	PAN
	Intermediate/Insensitive	F
NRCC (15019)	Sensitive	Salt
NRCC (18467)	Sensitive	H_2S
NRCC (18132)	Sensitive	V
NRCC (15391)	Sensitive	As
NRCC (16743)	Sensitive	Cd

Strawberry

Reference	Rating	Contaminants
EPA	Insensitive	O_3, SO_2
	Intermediate	F, $HC\ell^2$
APCA	Insensitive	F, H_2S
NRCC (18467)	Insensitive	H_2S
NRCC (15391)	Sensitive/ Intermediate	As

Sunflower

Reference	Rating	Contaminants
EPA	Sensitive	NO_2, $C\ell$, NH_3, Hg
	Intermediate	F
	Insensitive	H_2S
NRCC (18467)	Intermediate	H_2S

Tomato

Reference	Rating	Contaminants
EPA	Sensitive	O_3, PAN, SO_2, 2,4-D, $HC\ell$
	Intermediate	F, NO_2, $C\ell$, Hg, ethylene
	Insensitive	NH_3
NRCC (19252)	Sensitive	Ag
NRCC (15019)	Sensitive	Salt
NRCC (18467)	Sensitive	H_2S
NRCC (15391)	Insensitive	As
NRCC (16743)	Sensitive	Cd
AAAS	Sensitive	O_3, PAN
NRCC (15015)	Intermediate	SO_2
M & F	Sensitive	NO_x (Indicator plant)

Wheat

Reference	Rating	Contaminants
EPA	Sensitive	O_3, SO_2
	Intermediate	PAN, F, NO_2
NRCC (19252)	Sensitive	Zr
NRCC (15019)	Insensitive	Salt
NRCC (15391)	Insensitive	As
NRCC (16736)	Intermediate	Pb
NRCC (15015)	Sensitive	SO_2

APPENDIX B

FIVE-YEAR AVERAGE VALUE PER HECTARE OF SELECTED CROPS BY COUNTY

Sensitive Crops	$ Value/Hectare		
	Niagara	Haldimand-Norfolk	Hamilton-Wentworth
Soybeans	535	535	570
Sunflowers	n/a	n/a	n/a
Corn for ensilage	575	615	583
Tame hay	330	343	378
Oats for fodder	173	183	188
Other fodder crops	173	183	188
Dry field beans	n/a	n/a	n/a
Asparagus	3120	3120	3120
Beans (wax-green-snap)	3468	3468	3468
Broccoli	5120	5120	5120
Cabbage	5203	5203	5203
Cauliflower	6398	6398	6398
Cucumber	4063	4063	4063
Lettuce	7968	7968	7968
Tomatoes	4298	4298	4298
Apples	3298	3298	3298
Pears	3765	3765	3765
Plums and prunes	3550	3550	3550
Cherry (sweet)	4995	4995	4995
Cherry (sour)	4995	4995	4995
Peaches	4085	4085	4085
Apricots	4150	4085	4085
Strawberries	8383	8383	8383
Grapes	2190	2190	2190
Improved pasture	110	113	125

n/a - not available

Note: Calculated from Agricultural Statistics for Ontario, Publication 20, 1978-82.

Sensitive Crops	$ Value/Hectare		
	Brant	Halton	Peel
Soybeans	625	n/a	535
Sunflowers	n/a	n/a	n/a
Corn for ensilage	588	505	470
Tame hay	373	300	323
Oats for fodder	190	190	188
Other fodder crops	190	190	188
Dry field beans	n/a	n/a	n/a
Asparagus	3120	3120	3120
Beans (wax-green-snap)	3468	3468	3468
Broccoli	5120	5120	5120
Cabbage	5203	5203	5203
Cauliflower	6398	6398	6398
Cucumber	4063	4063	4063
Lettuce	7968	7968	7968
Tomatoes	4298	4298	4298
Apples	3298	3298	3298
Pears	3765	3765	3765
Plums and prunes	3550	3550	3550
Cherry (sweet)	4995	4995	4995
Cherry (sour)	4995	4995	4995
Peaches	4085	4085	4085
Apricots	n/a	n/a	n/a
Strawberries	8383	8383	8383
Grapes	2190	2190	2190
Improved pasture	123	100	108

APPENDIX C

VALUE OF RELATIVELY SENSITIVE CROPS WITHIN THE O.W.M.C. CANDIDATE AREAS

ENUMERATION AREA	$ VALUE/HECTARE
FT. ERIE	
018	72.00
021	50.40
A*	9.60
PORT COLBORNE	
B*	91.20
062	33.60
059	50.40
WAINFLEET	
115	57.60
116	57.60
117	139.20
118	208.80
119	72.00
120	64.80
121	59.30
201	209.63
202	135.95
LINCOLN WEST	
203	138.40
204	138.70
205	121.78
206	190.28
207	114.50
208	210.18
209	72.00
210	156.00
211	141.60
212,213,214	108.00
215	206.40
216	187.20
168,169	162.00

*A = FT ERIE 003, 006, 019, 020, 022, 053
*B = PORT COLBORNE 060, 066, 061, 112,

ENUMERATION AREA	$ VALUE/HECTARE
LINCOLN	
004	355.20
010	216.00
012	180.00
THOROLD	
113,114	108.88
112,151	33.43
NIAGARA FALLS	
001	20.33
002	56.03
003,010	43.18
078	88.75
WELLAND	
002	45.33
001,051,052	35.68
PELHAM	
167	163.20
164	357.30
163	835.03
160	129.60
159	57.60
HALDIMAND	
058	122.40
059	132.00
063	88.80
064	115.20
065	91.20
103	117.60
104	127.20
105	108.00
106	144.00
113	117.60
114	79.20

ENUMERATION AREA	$ VALUE/HECTARE
DUNNVILLE	
003	83.53
054	149.03
055	98.40
057	121.83
ONONDOGA	
011	149.70
012	194.80
019	95.98
STONEY CREEK	
151	321.60
152	160.80
GLANBROOK	
001	96.00
002	67.20
004,005	117.60
006,008	105.60
007,003	91.20
011,010	74.40
012,013	93.60
015	110.40
016	93.60
018,017	88.80
101,014	72.00
ANCASTER	
103	129.65
104	304.98
105	120.98
C*	62.78
106	69.90
NANTICOKE	
208	72.00
209	110.40

C* = ANCASTER 116, 112, 113, 114

ENUMERATION AREA	$ VALUE/HECTARE
BRANTFORD	
014	333.60
MISSISSAUGA	
268	28.80
273	14.40
MILTON	
167	32.10
166	96.60
165	62.63
164	389.48
169	143.93
BURLINGTON	
264	116.05
265	226.43
267,268	74.16
CALEDON	
364	259.20
301	118.83
BRAMPTON	
201	57.60
302	45.60
303	79.20

GLOSSARY OF TERMS USED IN THIS REPORT

Accumulation - Forming an increasing mass or quantity over time; increasing tissue concentration of contaminant(s) with time.

- Bioaccumulation - Increasing mass or quantity in the living system as a result of cell or tissue processes, translocation, food chain enhancement; all increasing tissue concentration of contaminants over time.

Contamination - Addition of pollutant(s) or toxicant(s) to plants.

- Environmental contaminant - A pollutant or toxicant in the region containing the plants of concern.
- Direct contamination - Addition of a toxicant or pollutant to plants or plant parts as a result of spatially uninterrupted deposition without intermediate agents.
- Surface contamination - Addition or deposition of a toxicant or pollutant to the exposed outside limits of the plant body.

Crop characteristics - Traits or qualitites of cultivated plants that affect their sensitivity to toxicant-induced injury or affect their role in food chain concentration or transmission of accumulated toxicants.

Damage - A measure of the decrease in economic or aesthetic value resulting from plant injury by pollutants.

Dose-response relationships - A stimulus in terms of a measured concentration of a toxicant for a known duration of time (concentration per unit time) to which a plant is exposed and the action or change elicited by this stimulus.

Food chain - A series of organisms, each one dependent on the previous organism in the series for substances to maintain life and growth. Accumulated toxicants are passed from one organism to the next in the food supply chain.

Injury - Any change in the appearance and/or function of a plant that is deleterious to the plant (APS).

- Direct injury - Any change in appearance and/or function of a plant that is deleterious and that occurs as a result of spatially uninterrupted cause and effect, without intermediate agents or stages.
- Visible injury - Deleterious plant responses characterized by overt symptoms.
- Growth effects - Plant injury characterized by retardation of rates of increase in size, dry weight, and/or number of plant parts.

Plant morphology - The form or characteristic external appearance of plants in terms of numbers and relative positions of parts, including changes over time.

Pollutant (air) - Any gas, liquid or solid air contaminant that causes undesirable effects on living organisms or materials.

Quality - The degree of excellence of edible portions of crop plants; a measure of acceptibility as feed or food.

Sensitive - Reacting to pollutants or toxicants by exhibiting symptoms of injury.

- Sensitive crops - Cultivated plants that are prone to injury by toxicants.
- Intermediate - Plants, or particular plant tissues, that exhibit a degree of susceptibility to injury by toxicants or pollutants that falls between sensitive and insensitive.
- Insensitive or non-sensitive - Plants, or particular plant tissues, that are not susceptible to injury by toxicants or pollutants.

Sensitivity - The susceptibility of plants, or particular plant tissues, to injury by toxicants or pollutants.

- Absolute sensitivity - The existing, not relative or comparative, susceptibility of plants, or particular plant tissues, to injury by toxicants.
- Crop sensitivity - Comparative susceptibility of cultivated crops to injury by toxicants.
- Potential sensitivity - The susceptibility of plants, or particular plant tissues, to injury by toxicants that is cabable of coming into being or action.
- Relative sensitivity - Comparative susceptibility of different plants, or different plant tissues, to injury by toxicants.
- Relative risk - Comparative chance of injury or loss when exposed to toxicant(s).

Translocation - Movement of substances from one part of a plant to another.

Toxicant - A substance that kills or injures living organisms by its chemical or physical action, or by altering the environment of the organism.

- Toxicant emissions - Injurious substances emanating from a polluting facility.

POOR

QUALITY

ORIGINAL